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AUTHOR	Wang, M. Rachel
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ABSTRACT

This report describes a curriculum reform project conducted at Spokane Community College (Washington), which has extensive vocational programs and a high percentage of non-traditional students. The purpose of the project was to develop and test a series of student Learning Activity Packets (LAPs), which introduce fundamental chemistry concepts by engaging students in hands-on exercises. The reformed curriculum merges lecture and laboratory components of traditional chemistry and modern society, seeking to make connections to relevant issues from the students' perspectives which, in turn, encourages discovery of academic concepts and fosters student confidence. The hands-on curriculum covers fundamental concepts in chemistry, nutrition and food, and environmental and nuclear chemistry. Each topic contains eight to ten LAPs in order to insure both topical and modular knowledge. This report further details the LAP format, interactive laboratory exercises, first-hand experiences, the concept of writing-to-learn, and explains the instructor's role in the learning process. Student feedback on the reformed curriculum was measured via a survey designed to measure the effectiveness of course structure and content. Student responses were overwhelmingly positive, and over 90% indicated that they would take another such course in the future. (Contains 4 tables, 1 figure, and 35 references.) (CB)

Learning Chemistry in Laboratory Settings: A Hands-On Introductory Chemistry Curriculum for Non-Science Majors

by M. Rachel Wang, PhD

Spokane Community College, Spokane, WA

rwang@ctc.ctc.edu

(Presented online at the 1996 Teaching in the Community Colleges Online Conference: Innovative Instructional Practices.")

ABSTRACT: This report describes a curriculum reform project conducted in a community college with extensive vocational programs and a high percentage of non-traditional students. This curriculum merges lecture and laboratory components of tr aditional chemistry courses as one, in hands-on learning sessions directed by a set of comprehensive Learning Activity Packets (LAPs). The LAPs are grouped in topic modules, each centered on an aspect of chemistry in modern society. The topics include: fu ndamental concepts, nutrition and food, environmental, and nuclear chemistry. Class testing is being conducted in a series of chemistry mini-courses, each corresponding to a LAP module. Student responses are summarized.

In this paper, I wish to report an on-going chemistry curriculum reform project1 started in January 1995 at Spokane Community College (SCC), with the support of a Laboratory Leadership Development grant from the National Science Foundation (NSF)2. This curriculum project addresses some pressing needs in college chemistry at the introductory level, namely:

- the need to attract students to chemistry and science in general, instead of intimidating them and "turning them off"(1, 2);
- the need to connect chemistry with other fields of interest to the students (3 - 6);

- the need to emphasize first-hand experiences in scientific inquiry (7);
- the need to incorporate a variety of strategies to promote active learning (8 - 13), and accommodate different learning styles (14); and
- the need to provide a meaningful introduction for further studies (15).

Many worthwhile and innovative efforts have been initiated in recent years to revitalize introductory chemistry courses, including several major multi-institutional curriculum reform projects (16). The emphasis of this project is to develop and class-test a series of student Learning Activity Packets (LAPs), which introdu ce fundamental chemistry concepts by engaging students in hands-on exercises. This hands-on curriculum is not only laboratory intensive (17) and adopts a laboratory-centered approach (7, 18), it actually presents course content altogether in laboratory se ttings (19, 20). "Laboratory", as defined in a NSF program description (21), refers to "any settings affording students active participation in learning subject matter". The laboratory setting in this curriculum may involve a field study site, a library, a computer lab, a round-table meeting or presentation room, as well as the traditional laboratory. In the following sections, I will first describe briefly the background of this project, including an overview of Spokane Community College (SCC), where thi s new curriculum is being pilot tested. I will then discuss the series of new chemistry mini-courses designed for the new curriculum. These courses offer laboratory science credits towards the associates of arts degree at SCC. To illustrate how this hands -on curriculum addresses present needs in introductory chemistry courses, I will point out several specific features of the LAPs. Sample course syllabi are provided to show how these LAPs are scheduled in the mini-courses. Student responses to the mini-co urses and the hands-on curriculum are summarized.

Background of the Project

Institutional Background

Spokane Community College (SCC), located in Spokane, WA, is a two-year college with extensive vocational programs and a high percentage of nontradit ional students. SCC has a student population of 5,500 Full-Time-Equivalents (FTE) per quarter; about 2000 FTE take courses offered in the Liberal Arts Division. Of these 2000, 50% are pursuing a vocational certificate or an associate in applied sciences (A.A.S.) degree. The other 50% are pursuing the associate of arts (A.A.) degree, which allows direct transfer to four-year institutions as a Junior. In accord with the "open-door" policy of community colleges, SCC students do not need to achieve a certain academic standard before enrollment. Some depend heavily on developmental education to be brought up-to-speed for college level courses. Many are working adults returning to further their education or for re-training. A large percentage of them are sing le parents with many more obligations that compete with their studies than those facing traditional college students. Most of our students have little or no high school science background. Very few (less than 1%) come close to pursuing a career in the nat ural sciences. The majority of those who take science courses are pursuing careers in nursing and allied health sciences, and around 80% to 90% of theses are female.

Departmental Background

The Science Department at SCC is composed of nine full-time f aculty (five in life sciences, three in chemistry and one in physics), five to eight adjunct faculty (varies each quarter) and two full-time instructional laboratory technicians. All science courses are structured so that classes meet seven hours per wee k: three one-hour lecture sessions and two laboratory sessions, each of two-hour duration. The same instructor teaches both the lecture and laboratory sessions of a course. Class size varies from 25 in classes with students grouped into a single lab secti on, to

100 in classes with four-lab sections. A full-time instructor work load equals 18 contact hours, which usually involves three laboratory sections of students. The chemistry offerings serve over 250 students per quarter. Four types of first-year col lege chemistry courses are offered: the advanced general chemistry series (Chem 141, 142, 143) for science and engineering majors, the health science chemistry series (Chem 161, 162, 163) for nursing and allied health majors, a technical inorganic chemist ry course (Chem 130) for cardiopulmonary technology and respiratory therapy program students, and a survey of chemistry course (Chem 100) for liberal arts, business and some vocational program students.

The SCC Science Department has a reputation for solid and challenging course offerings. Our science courses are often the "filters" that screen out the weaker students. National reports indicate this "weeding-out" phenomenon is common for Freshmen science courses everywhere (1, 4, 22). On the one hand, we can attribute this phenomenon to the fact that the students we serve are generally unaccustomed to the rigor required of them in science courses. The weeding-out is necessary to maintain quality education and academic standard. On the other hand, ther e is an increasing awareness in the scientific community that we need to find ways to attract and retain more students in the natural sciences. We need to improve scientific literacy of the work force and increase technical capacity of the country. In the words of Stephen R. Lewis, president of Carleton College, Northfield, MN, Freshman science courses should be "not a filter, but a pump." (13) This awareness has caused many science educators, including myself, to question traditional practices in science teaching. Many recent reports have advocated curriculum reform to turn away from "the way we were taught".

With this view, we began to implement gradually what is known to work (3,13) in teaching and learning. Within the frame work of existing cour ses, we gradually build in hands-on learning,

making connections to relevant issues from the students' perspective, encouraging discovery of concepts and fostering student confidence. Aside from the lack of resources and personnel time for serious reform efforts in a community college, we have experienced limited success in some areas. We manage to "push and pull" a good percentage of many under-prepared students through challenging hard work and facilitate their success in subsequent course work. Their attitudes toward science change as a result. Written comments found in quarterly instructor and course evaluations give indications of this attitude change. A few of the comments are given below (unedited from original writing):

- *"This class makes me (my head) really think. This is not a class that someone can get through without a lot of studying. I find this class to be very enjoyable, but the hardest class I have ever taken."*
- *"I love the challenge that learning chemistry has become. As I progress I fe el a true sense of satisfaction because of the hard work required of me and my willingness to do the work. THRILL! (But not cheap.) I'm glad its a college level class not mediocre."*
- *"In some ways I think it has taken the romance out of life because I ca n now see there is a reason or a basis for everything. At the same time the information I have received has better prepared me to deal with the real world."*
- *"Learning that Chemistry is a part of daily events the chemical reactions that go on every second of the day to keep everything alive and going is amazing!"*
- *"Excellent! Dr. Wang has given me confidence that even I (with no previous science background) can comprehend chemistry!"*

Chemistry Courses at SCC

We have traditionally stressed the laboratory or hands-on component in all our courses. All full-time chemistry instructors develop a packet of laboratory exercises for each course he/she teaches; these are constantly being up-dated. Instead of the "recipe style" experiments now generally recogn ized as inadequate (18- 20, 23- 25), many of the exercises we develop are "interactive". A later discussion will describe this interactive style, which has become one of the distinctive features of the new hands-on LAPs. The two-hour laboratory sessions t wice a week allow more time for first-hand learning. Students are particularly responsive to this aspect of the course, as indicated by their written comments in course and instructor evaluations. The following typical comments are taken unedited from pa st student evaluations:

- *"I especially enjoy the lab work. Dr. Wang makes doing labs stimulating and fun instead of scary or boring."*
- *"The best part of Chemistry 161 is the lab time - it is very useful, and you have hands-on training and more time to wo rk out problems."*
- *"The labs really helped me learn the most."*
- *"Labs were not just educational but fun and interesting."*

Since 1990, we began to incorporate microscale (26) general chemistry laboratory exercises into our lab curriculum; and we curren tly run about 15% of the general chemistry labs in microscale. The one quarter Organic Chemistry (Chem 162) laboratory started using the microscale approach (27) as of Spring 1992. Along with necessary microscale organic kits, the Department acquired a FT -IR (PE 1605) and a second Gas Chromatograph (Gow-Mac) to support the microscale organic labs. In 1993, the Department purchased a complete set of electrophoresis apparatus useful for DNA and gene manipulation experiments (28) in biology (Bio 101) and bi ochemistry

(Chem 163) courses. We also replaced old Geiger counters with a set of six digital radiation counters for nuclear chemistry laboratory studies.

We have also adapted innovative teaching and course management methods to promote student succe ss. These methods include collaborative learning (28), students-teaching-students (STS) (29) (which is a step beyond collaborative learning), student initiated "dialogue-style" lectures that foster higher-level thinking, writing-to-learn (30, 31), classr oom assessment techniques (32), portfolio for assessment (33) , interdisciplinary studies (3, 18, 34), case studies, and others. We become aware of these methods mostly through faculty development workshops sponsored by a campus-wide initiative focusing o n student outcomes and assessment. This Student Outcomes project, funded by a Washington State grant, plays a major role in fostering a continual dialogue about teaching and learning on our campus. In developing the LAPs for the hands-on chemistry curricu lum, I have drawn from many of my classroom experiences in using these innovative teaching techniques.

Chemistry Mini-Course Series

The above background review clearly indicates the curriculum reform in this project is actually the culmination of a g radual process. Part of this process is a gradual shift from the traditional lecture-lab format of teaching introductory chemistry to a student-centered "laboratory learning" approach. This hands-on curriculum project simply accelerated this shift into a full-turn, by initiating a series of new chemistry mini-courses. This is a series of one to three variable credit courses under the general title of "Chemistry in Modern Society: Fundamental Concepts & Practical Applications". The uniqueness of these cour ses is that lecture and lab hours are not separate; they merge into one in hands-on learning sessions of two hours each. The new courses are: (1) Chem 110: Fundamental Concepts mini-course, a variable one- to two-credit course; and

(2) Chem 111,112,113: a series of topics-oriented mini-courses, each of variable one to three credits. Each mini-course requires around 16 hours class time per credit received. This is proportionally equivalent to the 77 contact-hours required for a five-credit traditional lab science course at SCC. By encouraging students to "try out" chemistry without a full 5-credit commitment all at once, we hope to attract, retain and educate them to the study of chemistry and science in general. Students usually take one mini-course per quarter. In two or three quarters, they will earn the five credits equivalent to a traditional physical lab science requirement for the Associates of Arts degree at SCC. Credits from these courses are also directly transferable to four year institutions; they are equivalent of a liberal arts chemistry course. This mini-course approach is particularly suited for those students who are working professionals, nonscience-oriented, not so sure about a four-year degree or are not ready to take on the challenges of traditional college science courses.

Our experience in offering the mini-courses for three quarters has confirmed that the mini-course approach affords flexibility in course scheduling. The variable credit format apparently has not caused any confusion or inconvenience at the registration office. The mini-courses were offered for the first time in summer quarter, 1995 with two options: (1) Chem 110, Fundamental Concepts of Chemistry, and (2) Chem 111, Chemistry in Nutrition and Food. Students receive one-credit after completing the first four weeks of a mini-course on a two-hour per session, twice a week schedule. Those who register for two credits continue with the same schedule for eight weeks, which equal the entire length of a summer quarter. In both Fall 1995 and Winter 1996 quarters, we offered the above two mini-courses plus an initial run of Chem 112 (chemistry in the environment). Chem 111 and 112 are available as variable one- to three-credit courses, meeting twice a week up to 12 weeks, which is the entire length of these two quarters. In Spring

1996, we plan to offer a section of Chem 110 in the night school, available as either one or two credits, meeting once a week for three hours up to 11 weeks of the quarter. In contrast to five-credit courses, the mini-courses are much easier to schedule in any given quarter of the year due to the variable-credit design.

The Hands-On Curriculum

As mentioned earlier, the hands-on chemistry curriculum consists of a series of student Learning Activity Packets (LAPs) on the chemistry involved in different aspects of our society. The LAPs are organized into several topic modules, each corresponding to the theme of a mini-course. I develop the LAPs with the help of several SCC faculty members and a few non-academic professionals. By design, the expertise of an advisor is in a field other than chemistry. For example, the advisors for the nutrition and food module included a registered dietician and two nutrition instructors. I will outline below a few specific features in these LAPs.

Topical and Modular Approach

Three topic modules have been developed during the first year of this project. These are: the fundamental concepts module, the nutrition and food module, and the environmental chemistry module. Additional modules being planned include a nuclear chemistry module, and a module combining other topics of interest to citizens and consumers. Each module contains eight to ten LAPs. The topical and modular approach of this curriculum is in accord with educational research findings that motivations for learning come from seeing the relevance of a subject matter (3). The topical approach connects chemistry to practical fields of interest to the students. The modular approach reinforces important chemical principles from different perspectives. For example, the concept of molecular polarity and the like-dissolves-like rule appear in almost every module. Students learn this concept in different contexts of solutions, vitamins, lipids, drug

absorption and cleaning products, etc. Competency in a subject eventually builds up when one sees it and understands it from all angles. The fundamental concepts module provides a foundation for the four application modules. However, it is not necessary to complete all the LAPs in the fundamental concepts module before starting an application module. For example, the nuclear chemistry module may directly follow the first fundamental concepts LAP on "Atoms & Molecules." Table 1 lists the fundamental concepts LAPs in sequence. Table 2 gives a sample LAP schedule in the mini-course corresponding to the nutrition and food module. This schedule selectively builds the fundamental concepts LAPs around the LAPs on nutrition and food. Table 3 shows a sample LAP schedule for an environmental chemistry mini-course. These sample LAP schedules allow each mini-course to start from the basics and develop its topical theme gradually. Students can take any mini-course with no prior exposure to chemistry.

LAP Format

The format of the LAPs is a mix between traditional laboratory manual and textbook. Each LAP has a central theme or subject which unfolds through short paragraphs of explanations interspersed with laboratory or hands-on activities. Main concepts are summarized in three or four learning objectives at the beginning of each LAP. Important terms and ideas are reiterated at the end in the Session Review section. Further studies and reading assignments follow as take-home work, to provide more breadth and depth to the subject in discussion. Students take the active part of learning by completing the LAPs; each LAP will require about two hours of class time. Some activities in these LAPs do not require laboratory space or equipment. These include instructor presentations, class demonstrations, peer teaching, small group and field studies. The experiments requiring laboratory space mostly use small scale materials and equipment, which have the benefits of safety, waste reduction, economics and time efficiency (26).

Interactive Laboratory Exercises

Many of the hands-on exercises in this curriculum are "interactive." Traditional laboratory experiences point students' attention to getting "good results" by following prescribed procedures. Students conduct observations and data collection in lab, and go home to analyze results and draw conclusions. They tend to go through laboratory procedures passively without grasping related concepts. The exercises in these LAPs aim at training students to become more careful observers and critical thinkers during the exercise. In many short, hands-on exercises, students test new ideas as they are being presented. They analyze results immediately, and are asked to answer critical questions concerning an experiment before the experiment is over. For example, a discussion of oxidation reduction reactions is directly followed by a laboratory exercise of tarnish removal from silverware by aluminum. As students observe the silver recovery process, they are balancing a redox equation between silver sulfide and aluminum. They identify which reactant is being oxidized, and which is being reduced. I attempt to develop each concept by considering how it can be simply illustrated with a hands-on activity. And, vice versa, I link each hands-on exercise to one or more concepts by asking pertinent questions during the activity to lead the students on.

First-Hand Experiences

The LAPs also include many activities in which students discover facts or derive ideas first-hand, instead of being told. These facts or ideas are presented traditionally through lectures, textbook reading or even demonstrations in a filmstrip or in class. All of these are "second-hand" learning experiences, because the learners are the "audience" and not the "players." In this curriculum, students are the "players"; they are given opportunities to learn first-hand for themselves as much as appropriate. For examples, students build molecular models to "discover"

the existence of isomers. They search a reference Elements Table to note trends of atomic mass and electronegativity. They perform a series of precipitation reactions and identify the most cost-effective way to remove silver from a silver-containing waste stream.

Writing-to-Learn

Many have reported the benefits of using writing assignments in chemistry courses (30, 35). These can enhance students' comprehension of concepts, improve communication between students and the instructor, and also serve as assessment instruments. I have used a variety of writing assignments in my own teaching, and have enjoyed seeing positive results. This is why I provide ample opportunities for students to write in these LAPs. These opportunities range from "Describe what you see in detail." and "Write a 50 to 100-word paragraph to explain ...", to one-page summary reports of laboratory, reading or field trip experiences, etc. In the one-page reports, I usually include specific guidelines or grading criteria to help the students focus their writing. Many instructors think writing assignments are time consuming to grade and hard to evaluate. This has not been my experience. I avoid excessive grading time by seeing writing assignments as a means to assess how my students think, and not trying to teach them how to write. Also, evaluation becomes easier with simple but specific grading criteria as suggested in these LAPs.

Instructor's Role

The LAP features described above naturally lead into a consideration of the instructor's role in using these LAPs. This curriculum is student-centered. The materials are for use mostly during class time. The focus of a LAP session is on learning, not on teaching. During a session, the instructor is a leader in the sense of a tour guide, a coach and a resource person (9). As a "tour guide", the instructor gives short presentations at different times during class to help students

grasp major concepts. He or she is there to point out what these "tourists" or "first-time visitors" tend to miss, if left on their own. As a coach, the instructor supports the "players" in the learning team(s) by keeping them on task, demonstrating proper techniques, and monitoring the progress of each one. As a resource person, the instructor provides a comfortable learning environment with necessary resources (materials and equipment, reference books, display items, charts or figures, guest speakers, etc.). He or she is available when questions or problems arise. Compared to traditional practices, the instructor is less of a "transmitter of knowledge", and more of a "facilitator for learning" (28). Needless to say, the instructor still assumes some other duties involved in traditional practices. He or she exercises foresight in selecting and scheduling the LAPs, decides on grading policy, administers tests, grades papers, etc.

Student Responses

Since this project emphasizes a student-centered curriculum, student responses are valued from the very beginning. I designed a survey to solicit student input in terms of course structure and content for the new mini-courses. 243 students who had never taken any college chemistry agreed to fill out a survey during winter and spring quarters, 1995. They were approached by two work-study students randomly on the SCC campus. The survey form includes questions concerning age, sex, intended major, science background, preference of mini-course topics and course scheduling. Analysis of the survey showed that students prefer two-hour per session, twice a week schedule. Among the mini-course topics given as options, several stood out (see figure 1). I noted with interest that fundamental concepts is among the top four topics of choice. This indicates a good percentage of the students simply want to learn some basics of chemistry, and we need not apologize for teaching chemistry for its own merit! As a result of this survey, I decided on the the two-hour class structure and topics for development.

The pilot classes from the past two quarters have consistently been very encouraging. Students are eager to learn, and over 90% of them indicated that they will take another mini-course in the future. Table 4 shows a summary of numerical and written comments from student evaluations of the mini-courses. Since this curriculum is still under development, these student responses have provided valuable feedback concerning course structure and LAP content. A few students have been particularly helpful in this respect. One of these students is a middle school teacher. She has taught eighth grade social studies and English for twenty years. With no prior exposure to chemistry, she decided to take the one-credit option of Chem 110 in the summer quarter to, in her own words, "enhance my overall learning ability." I asked her to monitor her learning in this class and record some observations. She identified an impediment in her learning process as being overly anxious when approaching new concepts. She often tries to "understand everything the first time all at once". As class progressed, her "capacity for comprehension did seem to broaden." She appraised the class as being "well structured, high interest and well paced." I find her report helpful in understanding how some "non-science" students feel when they first approach a science course. The mini-course format seems to attract other professionals like her. For example, a high school English teacher with a biology endorsement is currently (1996 winter quarter) enrolled in the late-afternoon Chem 111, nutrition and food mini-course. Though this student has taken life science courses for her biology teaching endorsement, she has no formal college chemistry background. She has agreed to serve as an expert learner in the class, and evaluate the curriculum as the course progresses. A later report of this project will include her observations.

Future Plans

Additional topical modules are under development in the second year of this project. In mini-course offerings, we anticipate that the topical nature of the mini-courses should be versatile in interdisciplinary study or learning community programs. We plan to offer chemistry mini-courses jointly with other academic disciplines such as biology, geology, art, history, communications, etc., in learning communities. Furthermore, we would like to encourage vocational programs at SCC to adopt a chemistry mini-course as part of their program requirements. One of the vocational programs in the Environmental and Health Science Division at SCC has already indicated interest in adopting the environmental chemistry mini-course next year.

After the LAPs go through their initial class-testing stage at SCC, they will be available for class testing in other institutions. Peer reviews of the first two sets of LAPs (Fundamental Concepts module and Nutrition and Food module) are being arranged currently through a publisher. I welcome questions or inquiries concerning this curriculum. In particular, I invite interested colleagues to class-test the curriculum in your institutions.

Notes

1. Part of this report was presented in a talk at the fourth annual Conference of the Washington College Chemistry Teachers Association in Portland, OR., November 1995.
2. NSF Division of Undergraduate Education Grant ILI-LLD 9452258.

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Figure 1. Student Interest of Mini-Course Topics: Survey Result

A Total of 243 students were asked to select three of the possible topics: fundamental concepts, nuclear chemistry, chemistry in the kitchen (with food, cooking), in art, in the environment, in medicine, in nutrition, in industrial use of materials, in household products, and in issues related to transportation (automobile and mechanical devices).

Table 1. A List of the Fundamental Concepts of Chemistry LAPs.

FC.1 - Atoms & Molecules FC.2 - Atomic Structure and Reactivity FC.3 - Chemical Bonding

FC.4 - Physical Changes & Intermolecular Forces FC.5 - Solutions FC.6 - Chemical Reactions

(1) FC.7 - Chemical Reactions (2) FC.8 - Carbon Compounds FC.9 - Acid Base Equilibrium & pH Buffers FC.10 - Mole Concept & Stoichiometry

Table 2. Sample LAP Schedule For Chemistry in Nutrition & Food

This is the current schedule for Winter quarter, 1996. The full schedule corresponds to a three credit mini-course. The review presentation sessions in the schedule are peer-teaching group activities, in which each student conducts a review over a section of course material for the others in a group. A student who has already gone through the fundamental concepts (FC) LAPs in a previous mini-course can skip the FC LAP series in this schedule and take a two-credit option of this course. If the student still desires to take three credits, he or she will do alternative activities which reinforce fundamental concepts during the FC LAP sessions.

Tuesday	Wednesday
Jan 2	Jan 3
	#1 Atoms & Molecules FC.1
Jan 9	10
#2 Atomic Structure FC.2	#3 Chemical Bonding FC.3
16	17
#4 Review Presentations	Quiz #1
	#5 Chem Reactions (1) FC.6
23	24
#6 Chem Reactions (2)	#7 Minerals NF.1
FC.7	
30	31
#8 Energy & Food NF.2	#9 Review Presentations
Feb 6	Feb 7

Quiz #2	#11 Solutions FC.5
#10 Intermolecular Forces	
FC.4	
13	14
#12 Carbon Compounds FC.8	#13 Vitamins NF.3
20	21
#14 Review Presentations	Quiz #3
	#15 Fats & Oils NF.4
27	28
#16 Lipids NF.5	#17 Carbohydrates (1) NF.6
Mar 5	Mar 6
#18 Carbohydrates (2)	#19 Review Presentations
NF.7	
12	13
Quiz #4	#21 Proteins (2) NF.9
#20 Proteins (1) NF.8	
19	20
#22 Food Additives NF.10	#23 Quiz #5
Review Presentations	

Table 3. Sample LAP Schedule For Chemistry in The Environment

Wednesday	Friday
Jan 3	Jan 5
#1 Atoms & Molecules FC.1	#2 Atomic Structure FC.2
Jan 10	Jan 12

#3 Chemical Bonding FC.3 EV.1	#4 Our Physical Environment
Jan 17	Jan 19
#5 Review Presentations	Quiz #1 #6 Water and Its Properties EV2.1
Jan 24	Jan 26
#7 Chem Reactions (1) FC.6	#8 Chem Reactions (2) FC.7
Jan 31	Feb 2
#9 Acid Base Equilibrium & pH Buffers FC.9	#10 Natural Water Systems EV.2
Feb 7	Feb 9
#11 Review Presentations or Field Trip	Quiz #2 #12 Hardness of Water EV2.2
Feb 14	Feb 16
#13 Carbon Compounds FC.8	#14 The Air EV.3
Feb 21	Feb 23
#15 Acidic Air Pollutants EV.4	#16 Analysis of Cigarette Smoke EV3.1
Feb 28	Mar 1
#17 Review Presentations Complete EV3.1	Quiz #3 #18 Municipal Solid Waste Management EV5.1
Mar 6	Mar 8

#19 Solid Wastes EV.5

#20 Hazardous Waste Management EV.6

Mar 13

#21 (To be announced.)

Mar 15

#22 Practical Uses for MSDS EV6.1

Mar 20

#23 Review Presentations

Quiz #4

Table 4 : Summary of Student Evaluation from Chemistry Mini- Courses

Numerical Ratings: Excellent 5, Very Good 4, Good 3, Fair 2, Poor 1, N/A 0

Two-hour sessions 4.27

Twice a week schedule 4.18

Eight sessions per one credit 3.6

Amount of work involved for the credit received 3.45

Grading policy in general 3.86

Requirement for Quizzes 4.21

Format of each session 4.05

Hands-on learning activities 4.27

Use of class time 4.05

Content Organization 4.21

Content level 4.23

Interest level 4.18

Helps me think through for myself 4.23

Style of learning activities 4.05

Usefulness of content 4.18

Amount I learned 4

Comparison between this course and other science courses:

Is this course easier or harder: 72% easier, 14% the same, 14% harder

Is this course more or less interesting? 79% more, 14% the same, 7% less.

Did you learn more or less in this course? 79% more, 14% the same, 7%

less Would you take more courses like this one? 93% yes, 7% no

Comments: (Students were asked to complete three sentences concerning the course.)

The best thing about this course is...

39% of the comments relate to "pedagogy." sample comments are:

The chem labs are excellent.

The hands on experiments (learn by doing)

the diversity of each weeks lesson

the basic nature of the material and it's format

has great potential for learning

that everything is explained in the papers and there is enough time to complete the lab.

We are able to work in groups.

25% of the comments relate to "relevance of course content." Sample comments are:

the way the concepts was presented was easy to understand. I especially like the way the science

lessons could be applied or observed in everyday life.

it's applicable to my daily life, very interesting class.

22% of the comments relate to the instructor. Sample comments are:

Instructor availability during class time & outside of class time.

the instructor does care

teacher is very helpful, wants the students to learn.

15% of the comments relate to the "mini-" aspect of the course. Sample comments are:

Little homework

Part Time

short time frame

The worst thing about this course is...

36% of the comments mention amount of work involved. Sample comments are:

the labs were great but maybe a little pressed for time

amount of homework for credits earned. for one credit I did as much or more homework than I did for my other ten credits.

Everything is so fast!

size of some packets

27% of the comments mention LAP content. Sample comments are:

Once in a while something is left out of the packet or skimmed over too lightly to answer questions adequately.

The length sometimes become tiresome. On some of the learning packets there are videos to watch which are not easily available.

23% of the comments mention needing more help. Sample comments are:

I believe some tutorial should be available to clarify student questions outside lecture & lab (perhaps extra credit for exceptional student(s) from more advance chem)

needs to be more lecture time to explain concepts of what we learned or were supposed to see during experiments

14% of the comments report nothing bad about the course. Sample comments are:

Nothing really that bad.

not more of them

Advice to other students taking this course...

64% of the comments stress the importance of class time and the LAPs. Examples:

do not fall behind, read material for next lab to understand procedure as time is short,br> Read material closely and make sure concepts are understood. If no help is available during class time seek help outside class time.

Study packets carefully, lots of information

Do not miss a day or you will be behind. Read the activity packets from front page to last.

Don't miss a class.

23% of the comments simply recommend the course. Sample comments are:

It's a good course before taking any other science classes.

Excellent quick & easy course for people who want to learn chemistry

Very good to get your "feet wet" with!

Very good course, if you want to learn about your nutrition & health.

10% of the comments mention the mind-set for class sessions. Sample comments are:

better come prepared to think

Be prepared to study a lot. Think!

Samples of Other comments:

Again, I liked the hands on labs, and being able to associate what was being taught to everyday life. An example would be how chemical changes versus physical changes. Another thing I appreciated was the fact we started at the basics and built up the knowledge base from there. By

not presuming what people know or do not know about science or chemistry, the above mentioned starting point will benefit everyone.

I found this course well designed for those students who lack good knowledge of high school chemistry or, like myself, have been absent from scientific academia for some time. I believe this should be a required course for all incoming science majors who could not pass (80%) test compiled of 100 questions from this course's test.

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Signature: [signature]	Printed Name/Position/Title: M. RACHEL WANG, Chemi Instructor
Organization/Address: Spokane Falls Comm. College MS 3180 3410 W Fort George Wright Dr. Spokane, WA 99224-5288	Telephone: 509 533 3654 FAX: 509 533 3856
	E-Mail Address: rachelw@spokanefalls.edu Date: 10-29-02

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